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Implications of geomagnetic field variation for the chronology of the Middle Later Stone Age and Middle Upper Paleolithic transitions

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The transition to ''modern'' human behavior is marked by the change from the Middle Stone Age (MSA) to the Later Stone Age (LSA) in Sub-saharan Africa and the Middle to Upper Paleolithic (MP/UP) in northern Africa and Eurasia. After the transition, ground bone tools and perforated ornaments become common and resource exploitation and socio-territorial organization patterns begin to resemble those of recent hunter–gatherers.

The transition apparently occurred around or earlier than 40,000 BP, which is near the limits of the radiocarbon dating technique. Calibration of Late Pleistocene radiocarbon dates with high precision U-series dating demonstrates radiocarbon dates are ~3000 years too young by 30,000 BP. This deviation reflects weakening of the earth's magnetic field strength. It was weakest at ~45–40,000 BP, during the Laschamp geomagnetic reversal event. Cosmogenic nuclide production increased during this event, making radiocarbon dates on materials formed after ~44,000 BP up to 3500 years younger than their true age. Older radiocarbon dates are unaffected by this event, so a gap in radiocarbon dates should occur around 42–38,000 BP.

The MP/UP transition in the Levant is dated on radiocarbon, TL and U-series to 46–43,000 BP, with a gap in radiocarbon dates *after* the transition. The oldest European UP sites have radiocarbon dates of 38–40,000 BP, but associated U-series and TL dates indicate the transition occurred around 42–40,000 BP, *within* the Laschamp event. In eastern Africa, the MSA/LSA transition apparently occurred earlier than 50,000 BP and perforated ornaments are radiocarbon dated to 39,900 BP. This is consistent with a tropical African origin for modern human behavior.

Paleoecological implications of faunas associated with hominids in the Turkana Basin, Kenya

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Inferences about the paleoecological requirements of hominids have been based on various methods, including functional anatomy, stable isotope analysis, paleocommunity analysis, and paleoenvironmental context. We report here an approach using a large database to generate testable hypotheses concerning hominid paleoecology based on the association or non-association of hominid fossils with remains of other species. An intensive study of published mammalian faunas at 342 localities in the Turkana Basin, northern Kenya, provides a dataset consisting of nearly 3000 species occurrences that was used to examine species associations. Co-occurrences of species in fossil assemblages are subject to many potential taphonomic biases and may not accurately reflect original ecological associations. We use two strategies to overcome this problem: (1) controlling for taphonomic factors known to introduce biases into paleoecological information, such as sedimentary context, body size, and time-averaging, and (2) using the large dataset to isolate trends that are statistically stronger than potential confounding taphonomic processes. As paleoecological indicators, we use species with ecological requirements that can be inferred based on functional anatomy and/or nearest living relatives, such as arboreal monkeys and grazing ungulates. Chi-square tests are used to determine the significance of negative or positive associations. Preliminary results indicate that

occurrences of *Australopithecus boisei* are less frequent than expected in faunas with arboreal monkeys. In contrast, *Australopithecus* ''non-robust'' appears to be more common than expected in such faunas, suggesting that its preferred habitat included riverine forest while *A. boisei* was associated with more open vegetation. The credibility of these results is supported by significantly low levels of association between arboreal monkeys and presumed open-habitat species such as *Antidorcas recki*, *Menelikia lyrocera*, *Ceratotherium simum*, and *Theropithecus brumpti*. Examination of turnover rates in different species associations in the Turkana Basin also can be used as to indicate variability in faunal responses to Plio-Pleistocene global climate change.

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Interpreting early hominid paleoenvironment based on the biogeography and adaptations of African Plio-Pleistocene monkeys

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In order to assess the usefulness of Old World monkeys for interpreting the paleoenvironmental context of early hominids, cercopithecoid communities at Plio-Pleistocene sites in eastern and southern Africa are compared in terms of species composition, dietary and locomotor diversity. Proportions of leaves and fruits consumed annually by fossil cercopithecoids were estimated by averaging predictions based on shear crest length, occlusal cusp relief, and degree of crown flare. A bivariate plot of the proportion of fruits and leaves consumed by fossil monkeys in three geographic regions, were then compared.

The analysis revealed a far greater diversity of cercopithecoid dietary adaptations in the Omo basin deposits (represented by Koobi Fora and Omo) than in more southern geographic regions, reflecting a wider range of forest and open habitats in this area. Whereas seven Omo basin and one South African species were found to be more folivorous/grammivorous than frugivorous, no such taxa were found in Southern Kenya/Northern Tanzania. Monkeys from Laetoli, Olduvai, and Olorgesailie have the lowest cusp relief and shear crest lengths of congeneric populations from other regions, reflecting the relative paucity of edible leafy foods and a narrow range of fairly open habitats in this area. Although numbers of species are similar in the Omo basin and southern Africa, South Africa was dominated by terrestrial baboons with comparable dietary and locomotor adaptations, revealing its environments to be more like that of Southern Kenya/Northern Tanzania.

The correspondence between inferences made about hominid paleoenvironments based on this study and those based on other methods, indicates that cercopithecoids are highly sensitive indicators of environment, especially when their dietary and locomotor adaptations are analyzed from a functional, population and community perspective.

Interview with a Neanderthal: an experimental approach to the role of blank morphology and prehension in Middle Paleolithic scraper manufacture

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Recent papers argue that blank morphology is a primary determinant of Middle Paleolithic scraper form. This paper tests this hypothesis by using both experimental replication and the

analysis of archaeological specimens to investigate the specific rules that govern Middle Paleolithic scraper manufacture. Twelve novice flintknappers, intentionally kept unaware of Mousterian scraper forms, spontaneously produced tools similar to Mousterian types in the position of initial retouch when provided with flake blanks and challenged to make a retouched edge suitable for scraping hide or planing wood. Interviews indicated that ease and comfort of prehension for the intended function of the tool combined with ease of retouch flake removal to determine the strategy employed in making each scraper. These factors generated two strong rules governing the initial retouch episode: (1) the platform and adjacent edges with angles approximating 90˚ are never removed; (2) the longest edge with the most acute edge angle will be retouched first.

Scrapers from Tabun, Le Moustier and Combe Capelle were found to conform to these rules in over 90% of cases. Among the many renewed specimens, transformations were consistent with the need to maintain an adequate edge for manual prehension. This confirms that a wide variety of Middle Paleolithic peoples employed the same scraper production grammar.

The demonstration that most Middle Paleolithic scraper types are generated by functional contingencies, the mechanical properties of stone, and the morphology of blanks, implies that scraper manufacture is fundamentally expedient in nature, and that the behavioral significance of scrapers lies more in function than form. Nevertheless, ''style'' in the Mousterian might be recognized in different production strategies. The discovery that Mousterian scrapers from Skhul, associated with early anatomically modern *Homo sapiens*, deviate significantly from these rules, may help differentiate these hominids behaviorally from the contemporary Neanderthals.

Aurignacian lithic economy in the lower Vézère Valley of France

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The archaeological record of the Vézère Valley in the Périgord is of monumental importance in the historical recognition of the antiquity of the modern human species, and the development of Paleolithic research. The nineteenth-century discoveries which led to this recognition and development unfortunately ensured that numerous site locations were subjected to poorly controlled exploration. Research at a number of sites during the latter half of the twentieth century has examined early Upper Paleolithic stratigraphic sequences, often with Aurignacian levels as basal components. A dedicated survey of geologic deposits within the Périgord by French and American researchers has located nearly 1000 potential lithic raw material sources.

Lithic economy during Aurignacian occupation at Le Facteur and La Ferrassie, when evaluated in comparison with data from the neighboring locus of Abri Pataud and the sites of Le Piage and Roc de Combe in the Dordogne Valle, reveals the primary importance of local subsistence environments and human settlement patterns. The coexistence of direct (''embedded'') and indirect (social exchange) procurement systems for different aspects of the Aurignacian material record is indicated. Geographical differences between Le Facteur and La Ferrassie are mirrored in varied intensities of material reduction, despite overall similarities in reduction stages. Certain forms of lithic retouch suggest temporal trends which emphasize the arbitrary nature of phase divisions within the Aurignacian.

All assemblages are dominated by raw materials available within a few kilometers. A modest increase in materials from distant sources—30 km and beyond—is apparent during the early Aurignacian. Faunal data from these early assemblages, although hardly ideal, indicate low diversities of species dominated by reindeer. These data suggest some Aurignacian groups adjusted mobility patterns in response to subsistence strategies.

New paleoanthropological discoveries and tests of hominid land use models in the Western Lacustrine Plain of the lowermost Bed II Olduvai Basin

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We report on the paleoenvironments of the Western Lacustrine Plain of the Early Pleistocene Olduvai Basin, and on the first *in situ* hominid specimen and Oldowan artefact and bone assemblages recovered from this portion of Olduvai's paleolandscapes. The paleoenvironmental and archaeological data derive from 12 trenches excavated in 1995 and 1996 into deposits attributed to lowermost Bed II. The trenches are distributed over a 3.2 km stretch of the western portion of Olduvai Gorge near Naisiusiu Hill. The hominid specimen, discovered in 1995, is a maxilla with the complete dentition of an adult individual attributed to *Homo habilis*. It was recovered in a perennial stream deposit along with abundant stone artefacts and a dense and diverse vertebrate and invertebrate fossil assemblage. The density and diversity of some of the stone artefact and fossil bone assemblages from the Western Lacustrine Plain are comparable to the richest assemblages we have recovered from lowermost Bed II deposits in the Southeastern Lacustrine Plain some 10 km to the east. The presence of a perennial stream and a rich biota in the west were not expected on the basis of Richard Hay's paleogeographic model of the Lowermost Bed II Olduvai Basin. Further, while fluvial processes helped to concentrate the remains in the west, dense artefact occurrences and numerous bones showing conspicuous signs of hominid butchery and bone breakage were not predicted by the hominid land use model that Peters and Blumenschine based on Hay's paleogeography. Volcanically desertified landscapes in the eastern part of the lowermost Bed II Olduvai Basin suggested by Hay's and Ashley's geological work may have made the southern and western landscapes of the ancient lake basin more attractive to Oldowan hominids, as suggested by Peters and Blumenschine's alternative land use model, and by the new data from the Naisiusiu area reported here.

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The effect of cortical thickness on mandibular torsional strength of South African early hominids

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Corporeal torsional properties are a potential source of information about primate trophic adaptations. The traditionally used analytic approaches, however, have limited ability to characterize these properties. This study explores a finite element model of the mandibular corpus. The cross-section was derived from a CT scan made through the M3 of a gorilla mandible. The periodontal ligaments were simulated as an elastic material with a uniform thickness of 0·5 mm. The model was constructed by extending the cross-section in the third dimension. This geometrical uniformity was purposefully maintained to keep that particular cross-section as the only morphological variable responsible for its mechanical behavior.

The results indicate that the torsional strength of a corpus depends substantially upon cortical thickness, and the largest stress occurs in the thinnest portion of the cortex. The overall stress field, however, is determined by alveolar properties. When alveolar bone is substantially less stiff than cortical bone, shear flows of opposite directions occur in the buccal cortex, similar to that in an open section under torsion. With the increase of the alveolar stiffness, the extent of these opposite shear flows reduces. The cross-section behaves like a closed section when alveolar bone is about 16 times stiffer than trabecular bone or the same as cortical bone. This study suggests the necessity of incorporating internal geometry for an accurate evaluation of structural strength and efficiency. Some apparently robust corpora of australopithecines have localized thin cortical segments with consequentially low torsional strength and efficiency. This may have implications for their dietary adaptations.

New excavations at Fontéchevade Cave (Charent, France)

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The Fontéchevade Cave has been well-known to paleoanthropologists since the middle of this century, when two hominid cranial fragments were found. These fossils, associated with a Tayacian industry, presumably dated to the last interglacial. New excavations at the site have been undertaken by the authors to clarify the chronostratigraphic position of the site, its depositional history, and the nature of the associated industry. This paper will present a summary of the results to date, including paleoclimatic links with the nearby sites of La Chaise and Artenac.

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Tool use in *Homo* and *Australopithecus*

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Previous authors have concluded, based on relative apical tuft breadth and morphology of the flexor pollicis longus (FPL) insertion region, that the early hominids *Paranthropus robustus* and *Homo habilis* were stone tool makers whereas *Australopithecus* spp. was not. Here we test both the proposed occurrence of these two traits among early hominids and the proposed functional association between flexor pollicis longus activity and stone tool making.

First, we compared apical tuft dimensions of Stw294, a terminal pollical phalanx of *Australopithecus africanus*, with those of modern humans, African apes, *Paranthropus robustus* (SKX5016) and *Homo habilis* (OH7). Our results show that the terminal pollical phalanx of *A. africanus* resembles those of modern humans, *Paranthropus*, and *H. habilis* much more so than those of the African apes in having a markedly expanded apical tuft. The terminal thumb phalanx of *A. africanus* also resembles those of *Homo* and *Paranthropus* in having a well-defined FPL insertion region. Second, we used electromyographic techniques to record FPL activity during stone tool production and use in six volunteers in order to test the hypothesis that peak FPL activity would be observed during precision grasping and stone tool making. We found no statistically significant difference ($P = 0{\cdot}19$, Kruskal–Wallis test) between peak FPL muscle activity recorded either during tool making and tool using or during precision and power grasping.

The paleontological evidence leads us to conclude that all hominids after 2·5–3·0 m.y.a. possessed both a well-developed flexor pollicis longus muscle and a relatively broad apical tuft on the thumb. No stone tools are, however, found in association with the first hominid (*A. africanus*) to exhibit these morphological features. We hypothesize that, rather than being directly related to stone tool making, the origin of this form-function complex is correlated with the evolution of more frequent, forceful, and precise tool using behavior in *Australopithecus*.

Evidence for plant exploitation at the Middle Paleolithic site of Starosele, Crimea

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Research into Paleolithic plant exploitation is generally lacking due to the common assumption that plant remains rarely survive in archaeological contexts. Recently, however, it has become increasingly clear that plant remains may be more common at archaeological sites than is generally believed, albeit at a microscopic level. New analytical techniques, such as lithic residue analysis, can help recover this potentially valuable source of archaeological information. A study of stone tool function using residue and use-wear analysis was conducted on a sample of artefacts from the Middle Paleolithic site of Starosele in the Crimea. In order to help assure the accuracy of functional interpretations, multiple lines of evidence were employed whenever possible. Artefacts were examined with reflected light microscopy ($\times$ 100–500 magnifications) for the presence of residues and wear patterns. Residues were identified based on morphological criteria derived from modern comparative collections and published sources. Wear patterns observed included edge damage, striations, and micropolishes. Polishes were

divided into two categories representing hard/high silica and soft use-materials. Many of the tools from Starosele exhibited plant residues including starch grains, raphides, and recognizable cellular plant structure. These plant residues were often found smeared back from the working edge of the tool in association with hard/high silica polish and striations. The patterning of the residues and use-wear on the tools suggests that the residues are related to tool use and are not modern contaminants. The large quantities of starch grains, found both on tool surfaces and within plant structures on the tools, suggest that some of the tools were involved in processing starchy storage organs such as roots or tubers. The application of residue analysis, in combination with more traditional analytical techniques, can aid archaeologists in understanding the too-often ignored role of plants in the Paleolithic.

Recent genetic evidence about human history

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While the original prominent inferences about human evolution from genetic data used mitochondrial DNA, today a variety of genetic systems with different strengths and weaknesses provide demographic information about our species' past. Several different systems provide a coherent picture of the number of ancestors of modern humans over much of the Pleistocene. The picture is that there were 3000–5000 reproductive adults in our ancestral population as long ago as half a million years, while there were not more than 30,000 a million to a million and a half years ago. These numbers are closer to long-term minima than to long-term averages. The implication is that the ancestors of our species would have occupied an area the size of, say, Lesotho, rather than any substantial part of a continent. The magnitude of continental differences among humans must have arisen between demes of less than 10,000 or so, implying either that the Pleistocene ancestral population was strongly subdivided as common chimps are today, else that colonizing populations were very small for a long time.

Menopause: evolutionary causes, fossil and archaeological consequences

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Regular food sharing between mothers and their children and long post-menopausal lifespans are among the features that distinguish humans from other primates. Elsewhere, we have proposed causal links between these phenomena, and demonstrated (using data on Hadza hunter-gatherers) fitness-related payoffs to post-menopausal women who provision weaned grandchildren. Linking these results with Eric Charnov's recently developed model of life history invariants has further allowed us to frame and test hypotheses about other distinctive aspects of human life history, including age at maturity, relative size at weaning, and birth rates, all of which display the expected effects of ''grandmothering''. Additional hypotheses are now offered concerning related variation in women's resource choice and habitat preference in the past. Fossil and archaeological tests for the emergence of this complex of traits are proposed. Implications for conventional arguments about key transitions in hominid evolution are identified.

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Middle Pleistocene hominid adaptations and paleoclimate chronologies in the Sahara

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Middle Pleistocene hominid adaptations in the eastern Sahara are reflected in stone artefact assemblages placed into two taxonomic groups, the Acheulean and the Middle Paleolithic. These artefact sets can be connected with lithostratigraphic sequences which provide a record of paleoenvironmental change characterized by pluvials (wet-episodes) alternating with intervals of aridity. Absolute dating and correlations with regional and global-scale indicators of climate change provide an opportunity to relate evidence of Middle Pleistocene hominid adaptation with paleoclimate chronologies. Hominid adaptations associated with Acheulean artefact sets likely continued to about 300,000 years ago and may in some areas of the Sahara persisted to about 130,000 years ago. The first appearance of Middle Paleolithic (or related Middle Stone Age) assemblages is after 300,000 years ago, and by the end of the Middle Pleistocene around 130,000 years ago they characterize the patterns of hominid adaptation.

Several alternatives may help to explain the variation observed in Middle Pleistocene artefact assemblages. Explanations of variation may be linked to spatial or temporal differences in hominid behavior, physical morphology, or responses to geoecologic or biogeographic changes. The artefactual variation may be connected to successional stages of capabilities and adaptations along the continuum from *Homo erectus* and early archaic *Homo sapiens* to more derived forms of *H. sapiens*, or the variation may be partially a result of adaptive strategies or task-specific behaviors connected to particular landscape-habitat contexts. We propose that evidence of changing Middle Pleistocene behavioral and physical adaptations in north Africa can be placed in a chronologic framework based on wetter paleoenvironmental conditions occurring in the eastern Sahara after global glacial termination events, during glacial to interglacial transitions.

Pliocene and Pleistocene sites in southern Narok District, southwest Kenya

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Survey in southwest Kenya above the western margin of the Gregory Rift Valley since 1994 has led to the discovery of LSA, MSA, Acheulean and possible Oldowan occurrences, as well as fossil-bearing sites representative of the early Pliocene. A long sedimentary sequence of airfall and waterlain tuffs, fluvial and lacustrine sediments and paleosols is exposed in the region of the confluence of the Ewaso Ngiro, Narok, Seyabei, Ntuka and Olonganaiyo rivers. At Lemudongo, a total of 278 well-preserved fossil bones and teeth of a variety of species including carnivores, primates, suids, bovids, hippopotamids, crocodilians, hyracoids and rodents, were collected in one day along a 70 m area of sediment outcrop. Three potentially datable tuffs are stratified within this 6 m-thick fossil-bearing paleosol. The presence of *Nyanzochoerus kanamensis* suggests this locality is older than 2·5 m.y.a. Four Acheulean sites have low densities of handaxes and cleavers, mainly made on phonolite, basalt and quartz. None are

clearly in primary context. Excavations at Ntuka River 3 have yielded a long sequence of new Early LSA microblade industries in discrete horizons that have high densities of well-preserved bones and teeth of equids, bovids, micromammals and humans. Paleosol stable carbon and oxygen isotope analysis at this site demonstrate substantial environmental changes through time in the 7·5 m sedimentary section. In the Ntuka area, Late Quaternary sediments contain numerous in-situ early and late MSA and early LSA sites with well-preserved faunas, a penecontemporary fossil carnivore den site and other fossil-bearing sites with minimally fragmented faunas associated with low artefact densities. This provides a rare opportunity to compare faunal and lithic resource exploitation patterns through time during the Middle and Early Later Stone Age, and to compare faunal exploitation patterns of humans and carnivores on the same landscape.

The evolution of endurance—toward a synthesis of skeletal and soft tissue evolution

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Soft tissue anatomy is too often ignored by paleoanthropologists. However, when modern human and non-human mammalian anatomy are compared, the differences can suggest patterns of adaptation not clearly evident from the fossil record. Features of the human integument, respiratory system, circulatory system, and digestive system are brought together in this discussion that suggest humans are uniquely adapted for extended periods of strenuous activity involving sustained high metabolic output. Our species has unique mechanisms for supplementing resting gas exchange, thermoregulation, and waste elimination. Digestive adaptations reflect a richer diet better able to sustain these higher energy expenditures. This review of published observations offers a new perspective on the evolution of the postcranial skeleton. It is now apparent that the shaping of modern bipedalism involved at least two structural revolutions—one by the early Pliocene that resulted in the Australopithecine pattern and a second one in the Late Pliocene that is evident in early *Homo*. We argue that the second adaptive shift reflects selection for increasing locomotor efficiency related to increased activity—perhaps long-distance travel or active hunting. If this hypothesis is supported, it would help bring together aspects of skeletal, soft tissue, and behavioral evolution.

Morphology of the *Australopithecus anamensis* lower deciduous first molar and capitate

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A deciduous first molar and capitate of *Australopithecus anamensis* were recently discovered from deposits at Kanapoi, northern Kenya, dated between 4·17 and 4·12 Ma. The dm1 was recovered in 1996, *in situ*, close to the site of the type mandible, KNM-KP 29281. This deciduous molar has relative length and breadth dimensions closer to *Ardipithecus* and the

African apes. The remaining enamel on the worn occlusal surface indicates that the cusp morphology may have differed from that of both *A. afarensis* and *Ardipithecus*.

The left capitate was discovered approximately 80 m from the type mandible site. It, like capitates of most other nonhuman catarrhines, has a laterally-facing facet for the second metacarpal. *A. afarensis* and *A. africanus* capitates, like those of *Homo*, have more obliquely oriented second metacarpal facets. This morphology would have permitted pronation of the metacarpal as in modern humans. In contrast, the second carpometacarpal joint in *A. anamensis* is unlikely to have allowed any significant degree of mobility. Not unexpectedly, the *A. anamensis* capitate, like that of apes and *A. afarensis*, lacks the recessed dorsolateral portion of the distal end for articulation with a third metacarpal styloid process. The *A. anamensis* capitate does not show the shift towards obliquely oriented joint surfaces seen in the wrist of later hominids including other australopithecines.

A single proximal manual phalanx, also from Kanapoi, shows a similar degree of length, curvature and development of flexor sheath attachments as do those of *A. afarensis*. These new hand bones combined with the previously known humerus, radius, and tibia of *A. anamensis* indicates that this earliest australopithecine was a habitual biped that retained some primitive features of the humerus, radius and manus.

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Hard hammer percussion manufacture of tools and early hominid hand morphology

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Seventeen hand muscles were monitored by electromyography in three subjects during videotaped replication of Oldowan and Acheulean tools by hard hammer percussion. The purpose was to identify muscles that are repeatedly and strongly recruited for this activity. These muscles guide us to skeletal features that are most likely to reflect specific muscle stresses associated with habitual hard hammer percussion in fossil hominid hands. Findings are the following: (1) fifth finger intrinsic muscle signals are consistently at top amplitude levels in both the hammerstone hand and the hand that maneuvers and stabilizes the core for hammerstone strike. (2) The first dorsal interosseus to the index finger and two intrinsic muscles of the thumb (variably flexor pollicis brevis and/or opponens pollicis) contract in the hammerstone hand at the highest levels. (3) The flexor pollicis longus muscle registers medium-high signals in both hands. We conclude that fifth metacarpal features relating to large intrinsic muscle contraction loads (e.g. relatively high robusticity and large joint surface areas) are valuable predictors of fossil hominid capability for habitual hard hammer percussion. Additional useful indicators are relatively robust index and thumb metacarpals with proportionately large proximal and distal joint surface areas (reflecting heavy intrinsic muscle recruitment). The proportionately robust fifth metacarpal from Sterkfontein (Stw 63) and the broad, flat *Homo habilis* (OH 8) trapezial surface for the first metacarpal are consistent with the large fifth finger and thumb intrinsic muscle contraction forces associated with hard hammer percussion in our experiment. Additional results of the experiment highlight the importance of thumb/finger pad movements (precision handling) in controlling hammerstones and cores, and reveal (through different recruitment patterns of experienced and less experienced subjects) possible sensorimotor adjustments to habitual hard hammer percussion tool making.

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Bridging the gap: connecting the origin of bipedalism in Pliocene Hominidae with the advent of semi-terrestrial adaptations among African Miocene Hominoidea

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Recent discovery of the primitive hominids *Ardipithecus ramidus* and *Australopithecus anamensis* underscores the need to gain further understanding of the locomotor adaptations of the Miocene precursors of Hominidae. *Kenyapithecus*, a large-bodied hominoid from the middle Miocene of eastern Africa, is of central interest in this regard. Seven field seasons of large-scale excavations at the middle Miocene site of Maboko Island (Kenya) between 1987 and 1996 have resulted in the discovery of numerous new remains so that the postcranial skeleton of *Kenyapithecus* is now the best-known of all middle-late Miocene African hominoids. Analysis of this postcranial sample reveals that *Kenyapithecus* was the first semi-terrestrial hominoid, with cursorial adaptations in the structure of the shoulder, elbow, hip, hallux, and phalanges. Models for the origin of terrestriality in Old World higher primates had predicted that the transition from life in the trees to life in the ground would be caused by a shift from forested to savannah habitats, from arboreal food resources (such as fruits and leaves) to ground-based foodstuffs (such as grass seeds, tuberous roots, and animal carcasses), and by a significant increase in body size. Reconstruction of the paleoenvironment, diet, and body size of samples from Maboko Island and Ft. Ternan, however, indicates that *Kenyapithecus* dwelled primarily in woodland, ate fallen fruits and nuts, and weighed approximately 20–30 kg (well within the range of arboreal anthropoids). A new model for the emergence of hominid bipedalism from the semi-terrestriality of *Kenyapithecus* results from comparison of these findings with the reconstructed paleoenvironments, diets and body sizes of *Ardipithecus ramidus* at Aramis and *Australopithecus anamensis* at Kanapoi.

Australopithecus africanus: out of step in the human parade?

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For decades *A. africanus* enjoyed center stage in the drama of discovering human ancestors. Robinson even referred it to *Homo africanus* since he believed it was clearly ancestral to later *Homo*. But the discovery of *A. afarensis* showed that including it as an ancestor of *Homo* meant an unparsimonious reversal in dental size and shape. That and other reasons led many to place *A. africanus* as a side-branch that gave *A. afarensis* the honor of direct ancestry to *Homo*. Formal phylogenetic analyses, however, consistently find that the most parsimonious cladogram is one in which *A. africanus* and early *Homo* are sister taxa relative to the more primitive *A. afarensis*.

New discoveries of postcranial fossils of *A. africanus* appear to show that its body may have been more primitive than that of *A. afarensis*, however. Why does the craniodental material place *A. africanus* as an ancestor to *Homo*, but the postcrania appear to be so primitive? At least

two explanations are possible: (1) the primitive postcrania of *A. africanus* is further evidence that this species is a side-branch and that *A. afarensis* is the direct ancestor of *Homo*. (2) These postcranial traits are less reliable indicators of phylogenetic affinity than are the craniodental features linking *A. africanus* and *Homo*. The first alternative implies that the *A. africanus* lineage diverged from the rest of Hominidae before the appearance of *A. anamensis* at 4–3·8 m.y.a. The second explanation may be more likely. Some of the apparently primitive characters of *A. africanus* postcrania may not be out of the range of variation seen in *A. afarensis* and early *Homo*, particularly *H. habilis sensu stricto*. Other characteristics may have less phylogenetic valence as judged by new discoveries in morphogenesis.

A reduction model for Acheulian bifaces

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Morphological variability in Acheulian bifaces is well documented after a century of excavation and analysis, but it remains largely unexplained. An analysis of several biface assemblages from northwest Europe shows a predictable and consistent relationship between biface size and shape. When previously published data from other parts of the Old World are reexamined, the patterns are identical. These results suggest that biface reduction strategies were remarkably consistent throughout the Middle Pleistocene and that biface morphology is largely a function of the intensity of bifacial reduction within limits imposed by raw materials.

Evidence for active hunting by early modern hominids at Klasies River Mouth, South Africa

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In this paper, I present a re-evaluation of the predatory competence of the early modern humans in the lowest layers at Klasies River Mouth Cave 1. I base my assessment on a stereomicroscopic study of the bone modification in the identified bovid assemblage from Cave 1. The frequencies and distributions of butchering marks, many of which went unrecorded in previous studies, strongly suggest that hominids were the sole systematic collectors of the bovids. Moreover, the hominids seem to have had unrestricted access to all portions of bovid carcasses in all size classes. A carnivore damage signature is present on some of the bones; but in frequency, locations and intensity it implies no more than occasional, opportunistic scavenging from the remains of animals already exploited by hominids. That the KRM hominids were actively hunting even the largest game in their environment is indicated by the tip of a stone point in a cervical vertebra of the extinct giant buffalo, *Pelorovis antiquus*. Active hunting is further suggested by a handful of marks on other vertebrae that may represent stabbing wounds. Finally, attributes of the patterning of butchering marks on the bones of eland, suspected of having been obtained by driving, suggest that the KRM hominids dealt with multiple carcasses in a more systematic way than they employed with single animals. These results challenge the perception that the earliest known appearances of near-modern morphology substantially antedate the appearance of modern behavior. Like their near-modern contemporaries elsewhere in Africa and southwest Asia, the KRM hominids made

typical Middle Stone Age/Middle Paleolithic tools; they produced no art, nor did they make artifacts in bone or ivory. However, the data presented here suggest that the KRM hominids were active hunters who regularly produced composite tools (polyliths) and who may have employed socially organized and mediated task groups in the accomplishment of labor-intensive tasks. To the extent that these behaviors presage the modern condition, the KRM hominids appear to have been as behaviorally near-modern as they were anatomically near-modern.

Variability in the patterns of dental development of *Australopithecus africanus*: a first approach

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The study of the dental developmental patterns of early hominids has received much attention during the last 10 years. Some authors have suggested a unique pattern of development for each of the main groups of australopithecines (namely *Australopithecus* on one hand and *Paranthropus* on the other), these differing from those of great apes and of modern humans. Other students point out the large variability in the dental developmental patterns of human populations, so that what can be observed in early hominids could very well be accommodated within the range of modern human patterns of dental development.

So far relatively few fossil specimens of a single species have been studied, thus ignoring the basic issue of intraspecific variability in the condition.

In recent study of the fossil hominids from South African sites, it has been possible to identify at least 23 juvenile specimens of *Australopithecus africanus*, with at least three developing permanent teeth that can be examined directly or through X-rays or CT scanning.

A preliminary analysis of the variability in the dental developmental patterns was carried out following the methods proposed by Smith (1994). The results suggest that:

(1) Within the species *A. africanus* some specimens turned out to have more ''ape-like'' patterns of dental development, while others have ''human-like'' patterns. Thus assigning isolated specimens to one of the two does not explain completely the situation as can be described in a species as a whole. Only when specimens are considered together, as part of a sample, some inferences on the dental developmental patterns of a fossil species can be drawn.

(2) The range of variability of the dental developmental patterns (as expressed by the coefficients of variation) of *A. africanus* only partially overlaps that of modern humans, from one side, and apes, from the other, reinforcing the hypothesis of a dental developmental pattern of these early hominids different from both humans and apes.

Deconstructing the Hadza carcass transport debate and its relevance to hominid foraging behavior

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Two groups studying the Hadza hunter–gatherers (Tanzania) have been engaged in a debate about large mammal carcass transport and processing. Bunn and colleagues see the Hadza as supporting the ''schlepp effect'' model of high limb transport away from kill/butchery sites

used to interpret zooarchaeological assemblages. In contrast, O'Connell and colleagues see little support for the ''schlepp effect'', citing higher transport of axial parts and patterned variability for different taxa. This impasse is rather vexing as both groups are studying the same people. Is it possible that different Hadza individuals transport carcasses differently, and that this accounts for the disagreement? Can Hadza carcass transport be explained by the ''schlepp effect'' or other cost-benefit considerations? And what are the paleoanthropological implications of Hadza carcass transport?

A re-analysis of Bunn's and O'Connell's data suggest that the conflicting patterns of carcass transport claimed by Bunn and O'Connell are not the result of behavioral variability among different Hadza individuals. The Hadza rarely transport carcasses according to the main predictions of the ''schlepp effect''. Rather, they typically transport entire carcasses (up to zebra size) and discard (defleshed and demarrowed) limbs at kill/butchery sites. In part, this patterning can be explained by reference to food utility indices (ratios of edible to inedible tissues by anatomical unit) and processing and transport costs.

Discussion focuses on the paleoanthropological implications of these findings. It is argued that when applying food utility indices to zooarchaeological assemblages from early hominid sites in particular, certain variables must be carefully considered: (1) the initial completeness of the carcass acquired by foraging hominids, which conditions food utility of a carcass; and (2) predation risk at carcasses, which conditions the extent of on-site food consumption, the number of available carriers, and ultimately, decisions about which parts to abandon. In some instances, these variables were likely significantly different for early hominids compared to the Hadza.

The significance of a uniqueness of Neandertal glenoid fossa shape reconsidered

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Neandertal scapula glenoid fossae have been described consistently as relatively narrow compared to the condition in modern humans, both in relation to the height of the glenoid itself, and when scaled against humeral joint surfaces (the humeral head and the distal articular surface). Most recently, these differences have been attributed to a decrease in upper-limb loading across the late archaic to early human transition, owing to selective pressures involved with the elaboration of projectile technology in the Upper Paleolithic. Hence, a widening of the glenoid correlates with the emergence of early modern humans and a significant increase in the frequency of throwing and projectile use. The present analysis re-evaluates this issue by way of comparison of glenoid morphology between Neandertals and three recent human populations. The results deemphasize the uniqueness suggested of Neandertal glenoid morphology by previous research. First, the relative width of the glenoid between Neandertals and one modern human population was found to be identical. Second, the narrowness of the glenoid relative to humeral joint surfaces in Neandertals was also noted among two modern human populations. These similarities may reflect responses to comparable biomechanical forces and general use of the upper limb and shoulder. This, in turn, may illustrate the extent to which the glenoid fossa can remodel in response to activity, a phenomenon recently noted among modern athletes.

Research on Plio-Pleistocene hominid activities at Kanjera South, Kenya

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This paper reports on the paleontology, archeology and isotopic chemistry of Bed KS-2, a Plio-Pleistocene deposit at Kanjera, Homa Peninsula, Kenya. The Kanjera deposits outcrop in the Northern, Middle and Southern Exposures. Kanjera North has long been known as the type locality of the giant gelada baboon (*Theropithecus oswaldi*) and as a source of controversial hominid fossils collected by LSB Leakey. Deposits there range in age from approximately 1·5 million years ago (Ma) to 0·5 Ma. The Southern Exposures, thought in the past to be coeval with those in the north, have been little studied. The sequence is composed of six beds (from oldest to youngest KS-1 to KS-6) deposited in the margin of a small lake. In 1996, this project initiated the first systematic excavations in Kanjera South. Biostratigraphy and magnetic stratigraphy indicate that KS-2 is at least 1·7 Ma and is possibly as old as 2·2 Ma, predating deposition in Kanjera North. A variety of fauna (bovids, equids, suids, hippopotamids) associated with artefacts were recovered from Excavation I, a 24 m^2 site in a KS-2 pebbly silty sand. The 12 m^2 Excavation II yielded a partial hippopotamus axial skeleton with artefacts in a KS-3 sandy silt. Cores from both sites were incidentally flaked and represent a Mode I lithic technology indistinguishable from the Oldowan. Preliminary analysis of site formation processes suggests that these accumulations were not formed through hydraulic activity and may reflect hominid behavior.

Stable isotopic analysis of KS-2 pedogenic carbonates suggests that Excavation I formed in a wooded grassland. The Excavation I fauna contains a high proportion of equids relative to Oldowan accumulations from Bed I Olduvai Gorge, Tanzania. Bed KS-2 thus seems to preserve traces of Plio-Pleistocene hominid activities in a more open setting than has been previously documented.

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Heterochronic process in dental development in Plio-Pleistocene hominids

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Some evolutionary changes in hominids are explained by heterochronic process. Misunderstanding on what really is heterochronic process and results led to some misinterpretation of changes in hominid evolution. Size, shape, and time of formation must be known for the individual or for a growth field to carry out analysis of heterochronic process. These three fundamental aspects of ontogeny can be obtained for dental enamel which is taken as a growth field.

The analysis of these aspects in Plio-Pleistocene hominid teeth from Omo, Ethiopia, ranging from 3·36 to 2·1 Ma, was carred out to see if changes through time in tooth crown are explained by heterochronic process.

Results suggest that heterochronic process have occurred in two opportunities in molars. Molars younger than 2·8 Ma show a size/shape dissociation producing a neoteny in relation

to older molars. Molars younger than 2·4 Ma present a longer time of crown formation without dissociation of size and shape. They are peramorphic by time hypermorphosis in relation to molars from 2·8–2·4 Ma.

Sidescraping, endscraping and the hominid hand

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This study compares the actions of sidescraping and endscraping to test an hypothesis that differences exist in muscle recruitment patterns for these two activities; differences which might be reflected in skeletal morphology. Three subjects had ten hand muscles monitored by electromyography during videotaping of these actions. The tools used remain constant across subjects. The endscraping implement represents a hafted tool while the sidescraping flake is unhafted. The results are as follows: (1) All grips for sidescraping are forceful precision grips. A power squeeze grip is consistently elicited during the use of the hafted endscraping implement. (2) For all three subjects, sidescraping recruits the flexor pollicis brevis muscle more heavily than does endscraping. (3) Two subjects had higher levels of recruitment for the opponens pollicis muscle during sidescraping than during endscraping. (4) Overall, the intrinsic hypothenar muscles are more active during endscraping than during sidescraping. (5) Neither activity recruited flexor pollicis longus beyond low to moderate levels. These results can be examined in light of the fossil record. Neandertal and modern *Homo sapiens* hand morphology differs in general robusticity as well as in the robusticity of certain muscle markings. Relative frequencies of scrapers also differ in the tool kits of these populations. Sidescrapers tend to be more prominent in the Neandertal tool kit, while endscrapers are more prominent in the modern *Homo sapiens* tool kit. During sidescraping, high levels of activity for the flexor pollicis brevis muscle (maximum in two subjects, moderate in the other) are consistent with the mechanical advantage gained by Neandertal thumb phalangeal proportions, indicating the importance of these proportions to forceful precision gripping rather than power gripping. Also during sidescraping, high activity of the opponens pollicis (at marked levels) for two subjects is consistent with the large opponens pollicis muscle crest seen in Neandertal first metacarpals.

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Early *Homo erectus* land use and future planning: inferences from lithic discard patterns across a 1·6 million-year-old paleolandscape at East Turkana, Kenya

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Several researchers have argued that the anatomy of early *Homo erectus*, as seen in the Nariokotome Boy (WT-15000) especially, implies longer home and day ranges, greater diet diversity, and more intensive parental care than in any other preceding species of hominid. In

addition, the body shape of WT-15000 implies that *Homo erectus* was adapted to open, dry environments. These hypotheses of hominid evolutionary ecology remain a challenge to be tested through the broadly contemporaneous archaeological record. Recent archaeological investigations from the Okote Member of the Koobi Fora Formation, Kenya dated to about 1·6 million years ago, including a landscape archaeological study of both surface and excavated records, provide clues for discerning early *H. erectus* land use and planning capabilities. The research reported here is based on field and lab work carried out in 1993–1994 and emphasizes the distribution of lithic artefacts in different subregions of East Turkana and among different depositional environments within the Karari subregion.

The distribution and character of the archaeological record differs significantly among four depositional environments (channel, levee, proximal floodplain, and distal floodplain) in somewhat unexpected ways. For example, whole flakes and cores from proximal floodplain settings show that they are the result of late lithic reduction stages, while artefacts from distal floodplain contexts, further from stone sources, show evidence of some early reduction. These differences are explored in reference to a modern-day environmental analog, the Kafue Flats of Zambia, providing probable paleogeographic and vegetation associations for different depositional environments. A general model of hominid land use is proposed that includes the anticipation of a future need for stone and flexible lithic reduction strategies contingent upon the sizes of stone available.

Middle Pleistocene human adaptations to the southern Chinese landscape

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This paper reports on the first full season (July–August 1996) of Sino-American excavations in Panxian Dadong, a large cave with stratified deposits located in the karstic region of the western Guizhou Plateau. The goals of the field season included establishing the site grid and mapping existing test units, clarifying the basic geology and complicated stratigraphy of the 8000 m^2 main chamber, expanding the test excavation units from the 1992 season, and clearing a large north-south trench for future investigations.

The uppermost undisturbed sediments in Panxian Dadong consist of alternating layers of travertines and clays, dated by U-series to approximately 300,000 BP. Geological and chemical analyses are underway to help verify this date and to investigate the depositional environment.

Preliminary analysis of the stone artefacts recovered in the 1996 field season indicates that the tools were fashioned on limestone, chert and basalt with the greatest number of artefacts made from limestone. The flaking technology is predominantly direct percussion and there is some evidence of core preparation. Basalt and chert were used more intensively than limestone, suggesting a differential use of raw material for tool production.

The Panxian Dadong faunal collection is characteristic of the southern Chinese Middle Pleistocene Ailuripoda Stegodon faunal suite. Some large genera, including Rhinocerus, Stegodon and Megatapirus, are well represented in the dental collection. Taphonomically, there is extensive evidence for rodent and carnivore damage, but hominid activity is also documented by the presence of burnt bone, percussive damage on large epiphyses, and a

few examples of cutmarks. Fossilization of the fauna appears quite variable. We are experimenting with different chemical analytical techniques to compare bone composition and processing.

Hunting strategies, weapon design, and Levantine Mousterian technological organization

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Whether or not Middle Paleolithic humans made and used hafted stone spear points has been the subject of considerable archaeological debate. If these points were a significant component of Middle Paleolithic technological adaptations, their occurrence in paleolithic assemblages should be correlated with structural variation in hominid subsistence strategies. An examination of the relationship between hunting strategies and weapon design suggests that stone-tipped spears should have been most abundant in contexts where hunting was highly time-constrained, and where enhanced the stopping power of hand-delivered spears would not compromise the functional versatility of a sharpened wooden spear. Data on the frequency of Levallois points (the Middle Paleolithic artefact-type most consistently associated with wear referable to spear point use) in 59 Levantine Mousterian assemblages generally supports this hypothesis. Levallois points are more common among assemblages from the steppic interior and southern Levant—where food resource variation was highly seasonal and where few plant foods were available to offset hunting failures. Levallois points are less common among assemblages from the humid northern and coastal Levant—where food resource fluctuations were less seasonal and where numerous alternative food sources were available. These data suggesting that the close relationship between land-use strategies and hunting weapon design seen by many as an emergent feature of the Upper Paleolithic is actually a significant feature of the Middle Paleolithic archaeological record as well.

The mandibular symphysis of *Australopithecus*

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It is well-known that australopithecine mandibular symphyseal anatomy includes many pongid-like features. To examine this morphology more closely two analyses, one metric, one shape-based, were performed. Initially, mandibular and cranial data were gathered from adult humans, gorillas, common chimpanzees, and orang-utans from the Hamman-Todd Collection, Cleveland Museum of Natural History and bivariate statistics were analyzed. These consistently pointed to the well-known major differences between humans and apes, but also allow us to formulate hypotheses concerning what accompanies or, perhaps, determines change in mandibular symphyseal morphology in hominid evolution. Early (ca. 4 Ma) *Australopithecus* specimens have a low angle between the long axis of the symphysis and the toothrow plane. Later (ca. 3·5 Ma) specimens have a more vertical symphysis. All *Australopithecus* symphyses measured are relatively thick compared to great apes and humans and do not fall on the same allometric regression line. Next, Eigenshape analysis, a landmark free technique, was performed to measure shape differences. Midline mandibular symphyseal sections were made using Coltene President putty. These were digitized using an image

analysis system and Optimas software. Eigenshape analsyis was performed using the EIGENS program (Lohmann & Schweitzer, 1990). The first and second Eigenvalues (explaining 30·4% and 14·3% of the shape variation respectively) clearly discriminated between humans and apes. Within apes, gorillas and orangs cluster together to the exclusion of chimpanzees. Single outlines of *Australopithecus anamensis* and *A. afarensis* specimens were then entered into the analysis. The former group proved distinguishable from the modern sample, but, interestingly, were not intermediate between apes and humans. The latter group clustered within the gorilla–orang group.

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^{87}Sr ^{86}Sr ratios in modern and fossil foodwebs of the Sterkfontein Valley: implications for early hominid habitat preference

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Heavy isotope ratios such as $^{87}Sr/^{86}Sr$ are not measurably fractionated by organisms. As a result the $^{87}Sr/^{86}Sr$ of plants and animals reflects the ultimate source of strontium in foodwebs.

Previous study in the vicinity of Swartkrans and Sterkfontein has demonstrated that, while there is considerable variability in the $^{87}Sr/^{86}Sr$ of whole soils within a 15 km area from these sites, *available* soil $^{87}Sr/^{86}Sr$ is generally between 0·730000 and 0·7400000. These values markedly differ from the $^{87}Sr/^{86}Sr$ of plants growing within the narrow greenbelt surrounding the Blaaubank stream and Blaaubank streamwater itself (0·721169).

The difference between *veld* and streamside Sr suggests a method for determining habitat utilization by early hominids, but this depends upon demonstrating that (1) modern $^{87}Sr/^{86}Sr$ relationships also existed in the Pleistocene, and (2) diagenesis has not substantially altered the original $^{87}Sr/^{86}Sr$ of fossils.

In this study, a geochemical explanation for a natural difference between Blaaubank and *veld* Sr is articulated. The model is based on relatively less radiogenic Sr in highly soluble dolomitic components when compared to other nearby geological substrates. The model was tested firstly using a ''top-down'' approach in which $^{87}Sr/^{86}Sr$ of water, soil and plants from the entire Blaaubank catchment was measured.''Secondly, a ''bottom-up'' approach was used using Swartkrans Member I faunal species known to have obtained their Sr from well-defined habitats. Thirdly, in order to explore diagenetic phenomena which might complicate applications, an isotopic dissection of Swartkrans Member I breccia was carried out, in which $^{87}Sr/^{86}Sr$ was obtained from carbonate, bone, and silicious components.

Together these studies make it possible to interpret the $^{87}Sr/^{86}Sr$ obtained from both robust Australopithecine and early *Homo* specimens from Swartkrans Member I.

Isotopic study of Pleistocene paleosols from the Olorgesailie Formation, southern Kenya rift

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The Olorgesailie Formation consists of 14 members deposited in a paleolake basin in southern Kenya. The 14 members are securely dated from 1·2–0·2 Ma, within a well-defined paleomagnetic sequence. Lake diatomites, paleosols with carbonates, tephras, and fluvial sands

occur in this sequence, which spans the time of *Homo erectus* through the transition to *Homo sapiens*. We recognize at least ten periods of soil formation within seven of the 14 members in this $\sim$100 km^2, $\sim$80 m thick formation.

Using the stable carbon isotopic composition of paleosol (buried soil) carbonate and organic matter, we reconstruct the proportion of woody vegetation (C_3 plants) to tropical grasses (C_4 plants) growing across the former land surfaces. During six periods of soil formation from $\sim$0·78–0·49 Ma, for example, pedogenic carbonate $\delta^{13}C$ values indicate a large proportion of C_4 plants were present on Member 7, 8, 9, 11, and 13 soils beneath open canopied grassy woodlands and wooded grasslands. Lateral sampling of members also shows variation in the percentage of C_3 *vs.* C_4 plants within the paleobasin. These results on younger Olorgesailie paleosols contrast with that from $\sim$0·99 Ma upper Member 1, where the majority of soil carbonate $\delta^{13}C$ values represent an open C_4 grassland setting with >90% C_4 plants. During the periods of soil formation in the younger members, paleosol carbonate $\delta^{18}O$ values indicate the Olorgesailie paleobasin was consistently cooler and moister than either upper Member 1 or today, supporting evidence for the greater abundance of less-arid-adapted woody C_3 plants.

These results indicate hominid toolmakers in the Olorgesailie paleobasin were not limited to a specific vegetational setting, but exploited a diverse array of floral habitats. Thus it appears that Pleistocene hominids were able to adjust to wide environmental shifts within local basins. Deep-sea records of global climatic change indicate the largest range of environmental variability during the late Cenozoic occurred over the past 0·7 Ma. Although discontinuous terrestrial records reflect local and regional conditions, and cannot be expected to mirror marine proxies of global climatic change, both records tend to support Potts' proposal of variability selection. His thesis predicts key ecological and behavioral innovations in hominids were correlated with spans of increased disparity in environmental (and selective) conditions, and enabled hominids therefore to occupy a wide array of habitats.

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A stable carbon isotope study of environment and hominid diet at Makapansgat Limeworks, South Africa

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The site of Makapansgat, South Africa, includes specimens of early *Australopithecus africanus*, as well as a faunal assemblage with a high proportion of ancient, extinct forms. The environment in the Makapan Valley at 3 Ma differed significantly from the later hominid sites of Sterkfontein and Swartkrans further south. Paleoenvironmental reconstructions vary but a recent study based on faunal analysis suggests a fairly closed, wooded habitat. The diets of the

hominids remain uncertain despite over 70 years of research; until recently dietary studies have relied of necessity on craniodental comparisons which have proven ambigious. The results of recent tooth microwear studies have been interpreted as suggesting diets of mostly leaves and fleshy fruits. Here we present the results of a stable carbon isotope study of the habitat and diet of *A. africanus* at Makapansgat. The relatively depleted isotopic signatures observed throughout the foodweb at Makapansgat are consistent with the interpretation of a woodland habitat. *Hyena makapania*, believed to be the main agent of accumulation of the Member 3 faunal assemblage, is isotopically depleted, indicating that its diet consisted mostly of C3 prey animals. Hominid signatures, however, are isotopically more enriched, indicating a significant ($\sim$50%) C4 contribution to the diet. The results suggest that besides the C3 fruits and leaves they ate liberal quantities of grass or, more plausibly, grass-eating animals, in contrast to later *Homo* and *A. robustus* from Swartkrans which had a smaller ($\sim$25%) C4 contribution.

Archaeological information preserved in Pleistocene-age bone protein residues

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This study addresses protein diagenesis in Pleistocene-age archaeological bone. Our sample comes from the Epipaleolithic Meged Rockshelter site and the Middle Paleolithic deposits of Hayonim Cave, both in the western Galilee, Israel. Amino acid analysis by high performance liquid chromatography (HPLC) indicates no intact collagen in specimens from these sites. Consequently, we aim to find archaeologically useful information that might be preserved in proteinaceous traces after collagen is gone. We focus on two problems. First, we investigate how the initial difference of heating versus no heating might lead to distinct diagenetic products tens of thousands of years later. Second, we attempt to identify chemically the diagenetic product; if intact non-collagenous bone proteins are detected and isolated, we would have a source for accurate biogenic stable carbon and nitrogen isotope values.

Amino acid analysis helps resolve the first problem. Meged and Hayonim bones identified as ''burned'' contain on average more free ammonia than do ''unburned'' bones. Also, apparently calcined bones typically exhibit a smaller total quantity of amino acids than do ''unburned'' or ''carbonized'' bones. Thus, even when collagen is not preserved, amino acid analysis can evaluate the accuracy of macroscopic visual criteria for distinguishing burned and unburned remains.

We approach the second problem—that of characterizing the diagenetic product—by decalcifying a set of Meged and Hayonim specimens and conducting a battery of analyses on the resulting organic fraction. We present molecular weight and functional group distributions—determined by HPLC and FTIR, respectively—for the bone organics. In addition, we report the immunological reactivity of the archaeological material to antisera from an extensive range of non-collagenous proteins. Overall, it is emphasized that a more thorough understanding of protein diagenesis in bone will be relevant to several topics of Paleolithic archaeological research, including site formation processes, paleoenvironmental reconstruction, and paleodietary analysis.

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A revised geochronology for the Plio-Pleistocene hominid-bearing strata of Sangiran Java, Indonesia

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The Sangiran area of Central Java, Indonesia is one of the best Plio-Pleistocene hominid-bearing reference sections of Southeast Asia because of its abundant hominid fossils, fairly continuous stratigraphic section, superposition of at least four distinct vertebrate faunas, interbedded volcanic rocks suitable for radioisotopic dating, and the presence of fine-grained sediments suitable for paleomagnetics. The hominid-bearing portion of the Sangiran section has been considered to range in age from about 700 ka to approximately 1·15 Ma (between the Jaramillo and Brunhes normal polarity intervals), based primarily on fission-track dates and magnetostratigraphic correlation. This calibration serves as the primary basis for the argument that hominids arrived in Southeast Asia no earlier than 1·0 to 1·1 million years ago.

However, 14 new $^{40}Ar/^{39}$ Ar dates on interbedded volcanic horizons at Sangiran indicate that hominids arrived in Southeast Asia substantially earlier. Laser incremental-heating of hornblendes separated from 14 pumice and tuff layers in the Sangiran section have yielded well-behaved $^{40}Ar/^{39}Ar$ plateau ages that range from 2·3 Ma for the middle tuff of the Puren Fm (Kalibeng) to 500 ka for a tuff in the middle part of the Pohjajar Fm (Notopuro). Seven tuffs in stratigraphic succession within the hominid-bearing portion of the Sangiran section have yielded $^{40}Ar/^{39}Ar$ plateau ages that range from 1·7–1·0 Ma. All 14 dates are chronologically consistent with their stratigraphic position indicating minimal reworking of the dated material. The sequence of dates is also consistent with a systematic series of paleomagnetics analyzed by our team using thermal and AF demagnetization techniques.

Ironically, the new dates indicate that all of the hominids from Sangiran are older, not younger, than 1 Ma. No hominids have been reported from above these dated horizons at Sangiran. The new dates permit the development of a revised chronology for the calibration of hominid evolution at Sangiran that ranges from 1·7–1·0 Ma.

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Relative postcranial development of Neandertals

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One aspect of the modern human life cycle, the adolescent growth spurt, is apparently unique to humans in that it involves a rapid increase in the rate of growth soon after the eruption of the second molar, resulting in an increase in linear dimensions of all parts of the skeleton including the face. Precisely when this life history event evolved is still unclear, but evidence from the dentition and postcrania of the early *H. erectus* specimen KNM-WT 15000, suggests

a more recent date for this phenomenon. Thus to address the question of when the modern pattern of adolescence evolved, we must turn to more recent hominids like the Neandertals of the Mid-Upper Pleistocene.

The use of modern human growth and development standards to appraise the age of the Le Moustier 1 Neandertal, based on dental eruption (ca. 15.5 years) and postcranial epiphyseal fusion and bone lengths (ca. 12 years), demonstrates a lack of concordance of estimates. This indicates that Le Moustier 1 was not maturing according to the same schedule as modern humans since his dental maturation was accelerated relative to his postcranial development. Stature estimates based on Feldsman's femur/stature of an adult male European Neandertal. This is in accordance with a modern human male just beginning his growth spurt. If Le Moustier 1's dental age accurately reflects his chronological age, then this individual would require a greatly accelerated growth velocity in the last few years of his adolescence in order to achieve the mean adult Neandertal stature. Analysis also demonstrates that some, but not all, of Le Moustier 1's postcranial proportions are allometrically scaled relative to adult Neandertals. This indicates that considerable proportional growth remained for this individual to achieve the body shape typical of adult Neandertals.

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Postcranial variation in extant hominoids with implications for interpreting hominid fossil assemblages

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Paleoanthropologists continue to debate the number of species in the hominid fossil record. Arguments of species recognition focus upon levels of variation exhibited within fossil assemblages. Most studies of variation and species recognition have concentrated on craniofacial and dental regions, while postcranial analyses have centered mainly on functional questions. Given the paucity of postcranial variability studies and the recognition of multiple craniodentally determined species at hominid Plio-Pleistocene sites, postcranial remains cannot be accurately assigned to different hominid species. In order to understand hominid fossil postcranial variation and thus attempt to designate species within fossil postcrania, an empirical framework based upon extant hominoid postcranial variation needs to be established.

This study presents morphometric data collected on the humerus, radius, ulna, femur and tibia of *Hylobates*, *Pongo*, *Pan*, *Gorilla* and *Homo*. Preliminary analyses using the coefficient of variation (CV) (Cope & Lacy, 1992; Plavcan, 1994) indicate most *Hylobates* forelimb variables display lower CV's than other quadrupedal hominoids. CV's for *Gorilla* variables generally are the largest, while *Pan* and *Pongo* CV's are intermediate. Further analyses will be conducted using the CV and the method of moments (Josephson *et al.*, 1996) on both forelimb and hindlimb elements. The patterns of variation displayed throughout the post-cranial skeleton will be discussed relative to differences in size, sexual dimorphism and locomotor behavior in hominoids. The comparison of variation in extant referent samples with fossil hominid postcrania provides a first step in interpreting hominid fossil variation and will help elucidate the presence of multiple species within fossil postcrania. The analysis of extant

data will be used to evaluate postcranial variation in the South African Plio-Pleistocene hominid sites of Swartkrans and Sterkfontein.

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Neandertals are a race of *Homo sapiens*

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Recent arguments by Kimbel, Rak, Schwartz and Tattersall once again propose that Neandertals are a separate species from fossil and recent *Homo sapiens*. While we accept the presence of some unique (or nearly unique) features in Neandertals, we also note that living populations of *Homo sapiens* express unique features (such as steatopygia or Uto-Aztecan premolars) which do not require these population's exclusion from recent *sapiens*. In addition, we present four lines of evidence why Neandertals must be considered an extinct race of *Homo sapiens*. (1) Improbable parallelisms: if Neandertals were a different species, their evolution must have involved detailed, inexplicable parallelisms to the evolution of *Homo sapiens*. Each parallelism is unlikely, together their improbability is multiplicative. (2) Evolutionary continuity: unique Neandertal features persist into post-Neandertal European skeletal populations, some extending to modern Europeans and others subsequently lost. Certain genes unique to Europeans also mark this continuity, showing greater antiquity in Europe than the currently proposed dates for the occupation of ''modern'' Europeans. Both examples require a measure of continuity through Pleistocene Europe. (3) Gene flow and mixture: continuous variation in morphological details of circum-Mediterranean Pleistocene fossils reflects genic exchanges among populations inhabiting the tri-continental Mediterranean rim. The marked variation of the Levant samples demonstrates that mixture with Neandertals was likely, if not usual. (4) Behavioral similarities: Neandertals and ''moderns'' do not differ behaviorally in any substantial way during the Middle Paleolithic of the Levant. Much later, the Châtelperronian Neandertals show every archaeological detail that is used to infer modern behavioral capacities in other Upper Paleolithic Europeans. While it is easy to identify a separate Neandertal species based on a few ''unique'' features, this interpretation results in important evolutionary contradictions which are unsupportable. We argue that Neandertals are part of our past, not distinct from it.

The Ebro frontier and the extinction of Neandertals

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Radiometric dates from several sites in Portugal and Southern Spain place the replacement of Mousterian industries by the Aurignacian at ca. 28–30 Ka BP. In Cantabria and Northern Catalonya, however, the earliest Aurignacian is now dated at ca. 38 Ka BP. Thus, a stable frontier corresponding approximately to the Ebro river valley seems to have separated Aurignacian modern humans from Mousterian Neandertals for at least 5000 years, and

perhaps as much as 10,000. This pattern is in good accord with the fact that all Aurignacian assemblages so far known in Portugal and Southern Spain are typologically late. No evidence of a tendency towards Upper Paleolithic-type lithic technologies exists in the late Mousterian of these regions, which has been shown on several grounds (sedimentology, micromammal analysis, paleovegetation) to be in the chrono-stratigraphic position occupied by the early Aurignacian north of the Cantabro-Pyrenean mountains.

This long coexistence without mutual acculturation forces a reappraisal of current models on the causes for Neandertal extinction. Recently, it has become commonplace to attribute this event to a biologically based intellectual inferiority of the latter. In the context of such models, the Chatelperronian and similar fully Upper Paleolithic cultural complexes associated with Neandertals have been explained as related to a phenomenon of ''imitating, but not understanding, modern symbolical behavior''. Such a phenomenon would have been the outcome of an acculturation of Neandertals, postulated as the inevitable outcome of any prolonged contact between them and Aurignacian modern humans. The Iberian pattern, however, contradicts the validity of such a postulate.

It would seem more parsimonious, instead, to approach the issue of the replacement of Neandertals by anatomically modern humans as a traditional problem of contact between isolated populations with different cultural trajectories. In this case, as has often been documented in both the historical and the ethnographic records, the long-term outcome of contact was that one of those trajectories was truncated and the corresponding genetical lineage went extinct.